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Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
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Method and apparatus managing data relative to an area corresponding to a work site

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Method and apparatus managing data relative to an area corresponding to a work site

The present invention relates to the field of worksite management, notably in civil engineering (construction sites, road building, urban development, etc.), landscaping, mining, etc., and aims more particularly at providing a method and apparatus for organising and exploiting different types of data that come into play in a worksite project. Worksite projects can be vastly complex and call for a wide variety of information from its initial planning phase to physical completion.

To assist in this task, it is known to use computer-aided tools for generating a target land contour for a worksite based on surveying data of the original contour of the land in question. These tools generate models from which elementary tasks can be assigned to various items of on-site earthmoving apparatus, the latter in some cases being automated to varying degrees. The earthmoving apparatus or its operator needs to be provided at all times with all the necessary information for conducting the task at hand at its location. This information will generally have various possible sources: a central model held at an on-site office, external devices such as beacons, laser guides, onboard sensors, and the like. As the task to be performed by an earthmoving apparatus is inextricably linked to its exact physical location, it has become usual practice to provide each item of mobile apparatus with a positioning device such as a GPS receiver and two-way communication links with different stations, or possibly other mobile apparatus on the site.

In this connection, US patent document 5 631 658 discloses a system for automatically operating geography-altering

machinery in a worksite on the basis of a preestablished three-dimensional model of the target contour relative to an existing contour. The latter is divided into elementary grid elements which can be indexed with the position of a contour-modifying tool of a particular earthmoving apparatus. A computerised system on board the earthmoving apparatus stores the site plan, identifies the current position and elevation of the contour-modifying tool using a GPS device, and automatically determines the actions to be performed with that tool to make the existing contour at that local level correspond to the target contour.

In the field of open-cast mining, US patent document 5 850 341 discloses a system for monitoring the removal of ore with reference to a three-dimensional map of the mine. The map is subdivided into elementary regions which are differentiated according to the type or grade of ore they contain, that information being acquired and recorded at an initial phase. The mobile excavating machinery is provided with a GPS receiver for positioning relative to the map and a sensor for detecting the amounts of ore removed. This information is correlated with the data concerning the ore to control the mobile excavating operations and keep track of the excavated ore.

In view of the foregoing, the invention proposes a new approach in which different items of information susceptible of variation as a function of position on a worksite are managed using a data array mapped on the topology of the worksite. The array can thereby be considered as a three-dimensional attribute data space (in the case where more than one type of attribute data is managed) which can be conveniently stored and segmented into smaller data structures in terms of topological coverage and/or type of data utilised.

From these data structures can be compiled individualised attribute data sets to suit different entities operating on the worksite, these sets being downloadable from a main management unit to specific entities according to current requirements, while maintaining a coherent and adaptive management of the overall data set.

Such a rationalised structuring of information can be used for organising and exploiting a wide variety of items of data which can be associated to identified sub areas of the worksite.

More particularly, the invention proposes, according to a first aspect, a method of managing data relating to a work site area, comprising the steps of:

- at an initial phase, establishing a set of at least one attribute parameter pertaining to an attribute of the work site, the attribute parameter having an attribute parameter value susceptible of varying as a function of position in the area,
- subdividing the area into elementary cells mapped in correspondence with the topology of the area,
- for at least one the elementary cell, determining the attribute parameter value at that elementary cell of at least one attribute parameter,
- storing attribute parameter values, each stored attribute parameter value being indexed to the elementary cell for which it was determined,
- determining evolutions in attribute parameter values, and
- dynamically updating the stored attribute parameter values on the basis of the determined evolutions.

The attribute parameter can express verified data or plausible

data concerning an existing state of the work site. An example of plausible data arises when the attribute parameter relates to a quantity that may have evolved and changed with time, so that it is not verified for the actual existing state of the site. For instance, the attribute data parameter can be the position of a cavity or conduit detected or created in the past, and kept on record. It may then remain plausible that the cavity is still present, but at a slightly different position, or partially filled owing to land movement. Another example is where the parameter was detected/measured with apparatus known to be subject to systematic or random error.

The stored attribute parameter values can be organised in a three-dimensional matrix of which the first and second dimensions map the topology of the work site area and define the locations of the elementary cells, and the third dimension corresponds to the set of attribute parameter(s).

An elementary cell can be dimensioned as a function of at least one of:

- the variation in contour at the cell,
- the variation in contour at the immediate vicinity of the cell,
- the rate of variation with respect to position in the value of at least one data to be managed,
- the type of tool(s) scheduled to operate in the area occupied by the elementary cell.

An elementary cell can, moreover, be dimensioned to be smaller than the footprint of a tool scheduled to operate in the area occupied by the elementary cell, whereby an attribute parameter value relevant for the operation of the tool can be obtained with a determined degree of accuracy.

Dimensions of elementary cells are variable over the work site area.

An attribute parameter can relate to elementary cell dimensions, expressed by the attribute parameter value(s) of that attribute parameter.

Attribute parameter values can acquired and communicated and/or stored by mobile apparatus as they are conducting site modifying tasks on the work site.

The data to be managed can be acquired and communicated and/or stored by mobile apparatus moving on the work site specifically for acquiring and communicating and/or storing the attribute parameter value(s).

The method can comprise the steps of:

- interrogating at least one source of dynamically updatable data on board the mobile apparatus, capable of delivering at least one current attribute parameter value,
- determining the geographical location at which the current value(s) is/are acquired, and
- storing the attribute parameter value(s) acquired at the interrogating step, in association with the cell corresponding to the determined geographical location, as an updated attribute parameter value.

The updated parameter value can be sent to a remote data management resource for dynamically updating the stored data values by the steps of:

- forming a message containing the attribute parameter value(s) and the geographical location data, and
- sending the message to the remote data management resource.

The message forming and sending steps can be performed on board the mobile apparatus.

The method can comprise the steps of:

- interrogating at least one source of dynamically updatable

data on board the mobile apparatus, capable of delivering at least one current attribute parameter value,

- determining the geographical location at which the current value(s) is/are acquired,
- associating and locally storing the current attribute parameter value(s) and the geographical location data on board the mobile apparatus.

The method can further comprise the step of uploading the attribute parameter value(s) and the geographical location data from the mobile apparatus to a remote data management resource at a determined updating moment.

The dynamically updatable attribute parameter value(s) can be acquired and communicated on-the-fly as the mobile apparatus evolves over the area.

The data to be managed can relate to physical or chemical characteristics of the work site and/or physical or chemical atmospheric characteristics of the work site.

The data to be managed can comprise at least one of the following types of data for the region occupied by a cell:

- ground humidity,
- ambient air humidity,
- ground temperature,
- ambient air temperature,
- ground density,
- outgassing characteristics,
- chemical or physical composition data of material,
- mechanical characteristic data of material,
- optical characteristics of material, e.g. colour,

reflectivity,

- qualitative information on at least one operation to be carried out, e.g. a cut or fill indication.

At least one dynamically updated attribute parameter value can be acquired by a sensor specifically provided for sensing that attribute parameter.

At least one dynamically updated attribute parameter value is inferred from operating parameters of a site-modifying apparatus operative in the work site area.

The attribute parameter value(s) can further comprise at least one attribute parameter value established prior to site modifying operations on the work site.

At least one attribute parameter value established prior to site modifying operations on the work site can relate to a non-dynamic land characteristic of the work site.

At least one attribute parameter value established prior to site modifying operations on the work site can comprise at least one of:

- soil type,
- land composition at a specified depth or depth range,
- possible existence of a buried conduit,
- indication of the type of buried conduit,
- possible existence of an underground cavity,
- indication of the type of underground cavity,
- recorded or supposed position of a buried conduit or underground cavity (e.g. depth, position within cell, etc.).

At least one attribute parameter value established prior to site modifying operations on the work site can relate to operating characteristics of the mobile apparatus.

At least one data value established prior to site modifying operations on the work site can relate to legal, administrative, or contractual data associated to the work site.

The legal, administrative, or contractual data can relate to at least one of:

- land ownership,
- insurance coverage,
- assigned contractor,
- task cost,
- task priority,
- legal status,
- possible existence of a toxic hazard,
- indication of archaeological interest.

An attribute parameter can also be a communications parameter, e.g. radio frequency, for exchanging data with a remote resource.

At least one attribute parameter can relate to a reference level, its attribute parameter value for a cell expressing reference level value with respect to which elevation/depth values are established for that cell.

The method can further comprise the step of preparing an individualised dataset specific to an identified site-modifying mobile apparatus, the individualised dataset comprising selected attribute parameter values for the requirements of that site-modifying mobile apparatus.

The individualised dataset can relate only to cells at, and in the immediate vicinity of, the site-modifying apparatus at a current geographical location of the latter.

The individualised dataset can relate only to cells of a

region of the work site where the site-modifying apparatus is programmed to be present over a determined time window.

The individualised dataset can relate only to attribute parameter data, among the stored attribute parameter values, which are relevant to the site-modifying apparatus.

The attribute parameter values can be centralised at a main database.

The attribute parameter values can also be distributed over plural distributed databases.

According to a second aspect, the invention relates to an apparatus for managing data relating to a work site area comprising:

- means, operative at an initial phase, for establishing a set of at least one attribute parameter pertaining to an attribute of the work site, the attribute parameter having an attribute parameter value susceptible of varying as a function of position in the area,
- mapping means storing a set of elementary cells which subdivide the area in correspondence with the topology of the area,
- means for determining the attribute parameter value at that elementary cell, for at least one attribute parameter,
- storage means for storing attribute parameter values, each stored attribute parameter value being indexed to the elementary cell for which it is determined,
- means for determining evolutions in attribute parameter values, and
- means for dynamically updating the stored attribute parameter values on the basis of the determined evolutions.

The optional characteristics presented above in relation to the method according to the first aspects are applicable mutatis mutandis to the above apparatus according to the second aspect.

The apparatus can further comprise means for acquiring the attribute parameter value(s), the means being at least one of:

- a total station type of surveying device,
- an aerial view sensor,
- a GPS (global positioning by satellite) device,
- An LPS (local positioning system).

The apparatus can further comprise data filtering means for selecting, from the stored attribute parameter values, those items of information relevant to at least one of:

- selected cells,
- selected site-modifying apparatus,
- selected tasks on the work site,

and means for sending the filtered information to targeted recipients.

According to a third aspect, the invention relates to a data base comprising a single storage unit or distributed storage units, containing attribute parameter values, the attribute parameter values being prepared specifically for the execution of the method according to the first aspect.

According to a fourth aspect, the invention relates a storage medium containing an individualised dataset specific to an identified site-modifying mobile apparatus, the individualised dataset being prepared specifically for the execution of the method according to the first aspect, and comprising selected

data elements of the attribute parameters for the specific requirements of that site-modifying mobile apparatus.

The individualised dataset can relate only to cells at, and in the immediate vicinity of, the site-modifying apparatus at a current geographical location of the latter.

The individualised dataset can relate only to cells of a region of the work site where the contour-modifying apparatus is programmed to be present over a determined time window.

The individualised dataset can relate only to a/those attribute parameter value(s) among the set managed data, which is/are relevant to the site-modifying apparatus.

According to a fifth aspect, the invention, the invention relates to a data carrier containing code executable by processor means, to cause the processor means to carry out the method according to the first aspect.

According to a sixth aspect, the invention relates to code executable by processor means, the code causing the processor means to carry out the method according to the first aspect.

The invention and its advantages shall become more apparent from reading the following description of the preferred embodiments, given surely as non-limiting examples, with reference to the appended drawings in which:

- figure 1 is a diagram showing the initial three-dimensional contour of part of a worksite, illustrating the position coordinates of an elementary cell C_i, taken randomly from the group of elementary cells into which the worksite is decomposed in accordance with the invention;
- figure 2 is a diagram showing the target three-dimensional

contour of the same part of the worksite as shown in figure 1, illustrating the aforementioned elementary cell C_i with its new position coordinates;

- figure 3 is a diagram illustrating how an elementary cell is dimensioned relative to the size of a contour-modifying tool used on the worksite;
- figure 4 is a schematic representation of a virtual space for containing attribute data referenced to a two-dimensional x-y plane on which the contour of the worksite is mapped;
- figures 5a and 5b are a schematic representation of an elementary cell and its associated attribute data in the virtual space of figure 4, in which figure 5b is a continuation of the virtual space interrupted at the bottom of figure 5a;
- figure 6 is a block diagram showing the main functional units that manage and exploit attribute data in accordance with a preferred embodiment of the invention;
- figure 7 is a symbolic diagram showing a mobile contour-modifying apparatus and selected elementary cells with their attribute data downloaded into an onboard memory of that apparatus as a function of its planned path;
- figure 8 is a block diagram showing the functional units used to produce an individualised attribute data set for a given mobile apparatus, from an attribute database containing a full attribute data set;
- figure 9 is a block diagram showing the functional units used to upload attribute data acquired by onboard sensors in a mobile apparatus to a central attribute data manager in accordance with the preferred embodiment of the invention;
- figure 10 is a block diagram showing a variant in which the

full attribute data set is physically stored over a number of distributed attribute databases; and

- figure 11 is a schematic diagram showing how multiple units of mobile apparatus can upload and download attribute data with respect to an attribute data manager in accordance with the preferred embodiment of the invention.

Referring to figure 1, the initial contours of a worksite 1 are acquired using standard surveying techniques to derive a three-dimensional computer readable map. Positions within the worksite are referenced with respect to a point of origin 0 and identified by three coordinate values along respective orthogonal x, y, z axes designated by reference numeral 2 in the figure. The surface S of the contour is subdivided into elementary areas, each corresponding to a cell. The figure shows one such cell C_{ij} whose central point has the coordinates Ix_i, Iy_j, Iz_{ij}, where the prefix "I" indicates that these coordinate values correspond to the initial contour of the worksite. The cells can be of uniform size, or they can vary in size over the site.

Figure 2 shows the same portion of the worksite as in figure 1 with the contours as they should appear at the conclusion of the earthmoving tasks. This finalised form is hereafter referred to as the "target" contour. In the illustrated example, the section contains a portion of road 3 with raised sides 5a and 5b. The cell C_{ij} of figure 1 is shown on this target contour. Being mapped against the same x-y coordinate plane, it retains the same x and y coordinate values Ix_i, Iy_j, but has a new z coordinate value Tz_{ij}, where the letter "T" indicates the target value for that z coordinate. Generally, the x and y coordinate values of any cell (generically designated by the letter C) in the map are invariable between

the initial and target contours, while the z coordinate value is likely to differ.

The dimensions of the elementary cells along the x and y directions are preferably made smaller then the dimensions of a site-modifying tool used on the worksite. This is illustrated by figure 3, which shows a blade 4 of a bulldozer having a width W occupying three contiguous elementary cells C_{ij}, $C_{(i+1)j}$, $C_{(i+2)j}$, the latter being partially occupied. This relative sizing of the elementary cells C allows the contour-modifying tool 4 to be positioned accurately with respect to the digital map represented by the set of elementary cells C. The skilled person can determine the appropriate mesh size (pitch of the cells along the x and/or y directions) of the thus-constituted grid according to the positioning accuracy required and the type of contour-modifying tools likely to be used on the site. It is also not necessary to have identical dimensions for each elementary cell.

For instance, if the initial contour and target contour of a given portion of the site are such that relatively large contour-modifying tools are expected to be used, then the cell dimensions at that location can be made correspondingly large. Conversely, if finer contour-modifying tools are envisaged for a particular portion of the worksite, or if that portion exhibits pronounced contour variations, then the dimensions of the elementary cells for that portion can be made correspondingly small to achieve the required precision.

In conformity with the present invention, each elementary cell C of the worksite is associated with a set of attribute data, generically designated hereafter by the abbreviation AD. An item of attribute data comprises an attribute parameter values for a specified attribute parameter.

As illustrated in figure 4, the attribute data AD are contained in an imaginary space referred to as "attribute data space" 6. In the representation used, the attribute data space 6 corresponds to a volume beneath a top layer portion 8 that expresses initial and target contour coordinate values on the x-y plane against which the worksite is mapped (this layer portion 8 shall hereafter be referred to as the "coordinate layer portion"). The AD space 6 effectively defines a three-dimensional matrix, in which two dimensions (x and y dimensions) serve to locate the cells. The attribute parameters are expressed along the third dimension z (vertical). In the representation, each attribute parameter is shown as a respective layer in the AD space 6. The AD parameter values for a given cell are thus the values at the corresponding successive layers along the z direction beneath the x-y coordinates of that cell.

Each elementary cell C thereby has an associated column 10 of attribute data values extending from the coordinate layer portion 8. This is shown in the figure for cell C_{ij}, for which the column 10 of AD parameter values is designated AD_{ij}.

The top surface of the coordinate layer portion 8, hereafter referred to as the "coordinate data layer", effectively maps the x-y plane of the worksite. This layer portion contains, for each cell:

- the x and y coordinates of the corresponding cell (e.g. the centre point coordinates, or position of a predetermined corner), and
- the target z coordinate value (i.e. the elevation at the conclusion of the earth-moving task) of the corresponding cell.

Thus, for cell C_{ij}, the coordinate data layer 8 is composed of a field containing a vector of three numerical entries respectively for the x, y, z coordinate values x_i, y_j and Tz_{ij}

(the prefix "T" indicates that the value refers to the target z coordinate value).

There shall now be described the implementation of attribute parameters associated to the cells. An attribute data parameter is expressed by an attribute parameter value, hereafter referred to as an attribute data value, or AD value. Figures 5a and 5a indicate the types of AD values used in the embodiment to constitute a complete attribute data set. Each AD parameter is assigned to a respective layer in the attribute data space 6. In the figures, these layers are represented for an arbitrary column 10 attached to an elementary cell C. Each layer of the column 10 stores one value or a group (vector) of values of attribute data to be associated to that elementary cell, and which quantify or qualify the corresponding type of attribute. For a given cell, a layer can in some cases be left blank, if its attribute parameter is not relevant or its value is not known for that cell. Where the cells have variable dimensions over the work site area, the dimensions of the cells can themselves constitute a member of the set of attribute data.

In the example, the AD parameters fall into four basic categories: real-time detected attribute data, pre-surveyed attribute data (figure 5a), task attribute data and administrative attribute data (figure 5b). Each category of attribute data occupies a number of layers in a respective section of the attribute data space 6, that number corresponding to the number of AD parameters belonging to the category in question. In figure 5a, the initial x and y coordinates are designated 8a, and the target z value is designated 8b, these values together forming the coordinate data layer 8.

The real-time detected AD parameter values (section of 6a of

the attribute data space) generally concern data gathered on the worksite while work is in progress. These data are typically acquired by specific sensors on board mobile apparatus that perform contour-modifying tasks, or by sensors that are provided specifically for data acquisition purposes. In the example, the real time detected attribute values are: material (e.g. soil) humidity (F01), ambient air humidity (F02), material (e.g. soil) temperature (F03), ambient air temperature (F04), soil or ground density (F05), chemical composition data of material (F06), physical composition data of material (F07), mechanical characteristic data of material (F08), optical characteristics of the material, e.g. colour, reflectivity (F09), outgassing rate (F10), and type of gas outgassed (F11). The last two parameters can provide valuable information on the soil characteristics (indicating for instance fermentation if an outgassing of methane is detected), or a possible leak in a fluid conduit.

The pre-surveyed AD parameter values (section 6b of the attribute data space) correspond to information acquired prior to the earthmoving tasks, and which generally indicate characteristics of the worksite on and beneath the surface that are useful to know. In the example, the pre-surveyed attribute data are: soil or ground type (G01), the qualitative land composition according to depth, respectively 0 - 0.2 metres (G02), 0.2 - 0.5 metres (G03), and 0.5 -1.0 metres (G04) below ground (from the initial contour), to produce cut information, an indication of a buried conduit (G05) (expressed as a Boolean yes/no), a code indicating the type of buried conduit (G06), an indication of an underground cavity (G07), a code indicating the type of underground cavity (G08), depth data in relation to a buried conduit or underground cavity (G09).

Another attribute parameter used in respect of a buried

conduit and/or cavity relates to the exact positioning within a cell (G10) and, if needs be, indications of possible positioning errors or drifts (G11). This parameter can thereby express positional precisions or uncertainties. For instance, the last record of a conduit or cavity may date from a time subsequent to which some local land movement may have occurred, or the records may have been based on error-prone techniques. The position data can then accommodate for this situation. It can also indicate the locations of conduit/cavity boundaries e.g. in terms of height/depth, x, y coordinates within the cell (G12).

The depth data can be referenced with respect to a universal/local height reference level. This reference level can be marked out by sweeping laser beams, ground markers, etc. In the example, the reference level is also one of the attribute data parameters managed for each cell or group of cells. Typically, this parameter value is a numeral expressing a height (positive or negative) of the reference level with respect to actual ground level at that cell (e.g. at the cell's centre) (G13). This numeral is updated at regular intervals so as continue to provide the correct reference level indication as the actual ground level of the cell changes, e.g. as a function of cut, dig or fill operations carried out.

The soil type parameter value is expressed as a code which uniquely corresponds to one of a set of listed possible soil types, for example clay, fine gravel, earth with chalk, etc. The correspondence between the soil type and the code are stored in a look up table accessible by the entities concerned. The ground composition data can, of course, be extended to cover greater depths as required.

The task attribute values (section 6c of the attribute data

space) generally correspond to parameter settings for both the end result of the surface and the machinery for producing that result. In the example, the task attribute values are: indications for dig/cut or fill operations (H01), which can be quantitative and/or qualitative, e.g. an extent indicated with respect to the reference level, the required slope of the surface along the x-axis (H02), the required slope of the surface along the y-axis (H03), the top surface finish required (H04), the type of apparatus (H05) and the type of contour-modifying tool (H06) to be used to conduct the task, servo control settings (H07)for the apparatus actuators, the radio frequency (H08) to be used for communications at the specific location of the reference cell concerned (in this case using e.g. a wireless local area network (WLAN)).

The administrative AD parameter values (section 6d of the attribute data space) correspond to a legal or contractual status associated to the land mapped by the elementary cell concerned. In the example, the administrative attribute values are: the land owner (I01), information regarding insurance coverage (I02), the contractor responsible for undertaking the contour-modifying tasks (I03), information for calculating a charge for the contour-modifying tasks (I04), a priority attribution for the tasks (I05), the legal status of the land (I06) (e.g. whether the land concerned is a nature reserve, council property, private property etc.), an indication of a possible toxic hazard associated to the land (I07) (e.g. radioactive waste), and an indication of a possible archaeological interest (I08). All these administrative AD parameter values are expressed in terms of pre-established codes corresponding to listed items stored in look up tables and accessible by the entities concerned. Naturally, for any of the above categories of attribute values, the list of AD parameters is open and can be modified dynamically to suit circumstances. It will be appreciated

that the term "value" used in connection with an attribute parameter (attribute data value) encompasses all possible descriptors as appropriate, these being e.g. numerical, verbal, identification codes, Booleans, etc.

Each data entry for an attribute data parameter value in any of the above categories corresponds to a value inputted into a pre-formatted computer-readable field. Depending on the nature of the attribute data concerned, the entered value can be in the form of: a number, an alpha numerical code value, a Boolean (e.g. yes/no), text, etc. These attribute data values thereby form a set of metadata indexed to a specific cell C.

It will be understood that the attribute data space 6 effectively constitutes a three-dimensional matrix of values, with two of its orthogonal dimensions defining a coordinate plane for locating each cell in direct correspondence with the x-y physical position of those cells. The third dimension (along the height axis of the columns 10) serves to define the different types of attribute data values to be associated with each cell.

Figure 6 shows in block diagram form how the aforementioned attribute data are managed and exploited during site-modifying tasks on the worksite 12. The management of the attribute data is allocated to an on-site office 14 at which are located the worksite's main intelligence and communications equipment. The activities of the on-site office 14 are centralised at a central management unit 16 which contains the main computer resources. Tasks which are specific to attribute data are decentralised at an attribute data manager unit 18 which is directly associated to an attribute database 20. This database stores dynamically the AD parameter values in the above-mentioned attribute data space 6.

The central management unit 16 also cooperates with:

- a mobile apparatus displacement manager 21 which: keeps track in real-time of the positions of each item of mobile apparatus on the worksite 12, determines the path to be followed by the remotely guided mobile apparatus as a function of high-level commands received through the central management unit 16, and generally regulates the traffic throughout the worksite to avoid collisions and congestions;
- an on-site communications manager 22 which handles high and low level tasks in connection with communications (message formatting, addresses, transmission protocols, frequencies, routing, etc.) for all the communicating entities on the site, whether it be between the communicating entities and the on-site office, or between the communicating entities themselves. To this end, the on-site communications manager 22 is associated to a communications interface 24 which contains the baseband and radio layers for wireless communication via an antenna 26 with the on-site communicating entities; and
- an off-site communications interface unit 28 which centralises all communications between the worksite and its outside environment using a number of different communication channels: installed telephone lines, radiolink via an antenna 30, and the Internet 32.

In the illustrated example, the off-site communications interface 28 uses the Internet to communicate with off-site offices 34. The off-site and on-site offices can thereby exchange data virtually in real time, e.g. for transferring commands, interrogating and updating databases, sharing computational tasks etc. Security measures such a virtual private network (VPN) tunnelling can be implemented as appropriate.

The hardware implementation of the on-site office 14 to

acquire, process and store the attribute data can be based on standard processor, memory and communications techniques.

The figure shows a bulldozer 36 as an example of a mobile apparatus which exploits attribute data in accordance with the invention. To this end, the bulldozer is equipped with onboard hardware and software (generally designated by reference 38) for communicating with the on-site office 14 and managing the attribute data at its local level. As will be explained in more detail further, the bulldozer 36 is provided with an individualised attribute data set that is limited to its specific requirements at a current time as concerns both its geographical location and the type of attribute data it specifically requires.

The onboard hardware and software 38 relevant for exploiting the attribute data comprise:

- an onboard central processing unit (CPU) 40 which centralises all the functional units of the bulldozer 36, associated with internal and external memories including a random access memory (RAM) 42 in which the local AD parameter values are stored;
- a global positioning by satellite (GPS) unit 44 associated with a satellite antenna 46 for acquiring the bulldozer's real-time position, speed and direction data. The GPS unit is pre-calibrated with a positional offset so that the positional coordinates acquired correspond to a fixed reference at the level of the contour-modifying tool used (in this case the blade 4). In the figure, the reference is a point RP located at the bottom of the blade 4, centrally along the width dimension of the latter. The reference position is established for a predetermined deployment configuration of the hydraulic rams operating the blade, for instance corresponding to the level where the blade makes contact with the ground when the bulldozer

is on a level surface. Positional changes of the reference point caused by movements of the ram (i.e. displacement of the blade relative to the bulldozer itself) can be taken into account from the hydraulic ram command data, so that the absolute position of the reference point RP can be determined all times to within the positional accuracy provided by the GPS system;

- a cell locator unit 48 cooperating with the GPS units 46 to identify the specific cell C of the mapped worksite at which the reference point RP is located. The correspondence between GPS coordinates and mapped cells is performed by standard techniques e.g. based on look-up tables or algorithms;

- a servo control unit 50 for controlling the motion of the blade 4 in response to received contour-modifying commands. This unit also sends the required relative blade position data to allow the GPS unit 44 to determine the appropriate offset, as explained above;

- a sensor management unit 52 which interfaces with all the different sensors that equip the bulldozer. Among these sensors are those which provide at least some of the real-time detected attribute values (section 6a of the attribute data space 6). Sensors on board the bulldozer 36 for providing real-time detected attribute values are in this example: an ambient air humidity sensor 54, a soil temperature sensor 56, a soil humidity sensor 58 and an outgassing rate sensor 60. Other types of sensors can be provided as required. Note that the bulldozer also delivers ground density attribute data, which it acquires indirectly from hydraulic pressure and ram response data at the level of the servo management unit 52;

- a local attribute data manager 62 cooperating directly with the onboard CPU 40 and specifically assigned the tasks

relative to the handling, distributing and updating of attribute data at local level. The items of attribute data for current or imminent use are formatted in that unit and stored in the RAM 42 of the onboard CPU; and

- an onboard communications interface unit 64 which manages all exchanges of data with the outside environment, notably with other mobile apparatus and with the on-site office, through the wireless local area network (WLAN) using an antenna 66.

In operation, the bulldozer 36 initially receives instructions for moving along a determined path. These instructions are downloaded from the mobile apparatus displacement manager 21 using the wireless local area network. The mobile apparatus displacement manager also uses the path information to determine the bulldozer's area of operation on the worksite for a determined time window in view of preparing an adapted individualised attribute data set. This information on the area of operation is sent via the central management unit 16 to the attribute data manager 18. In response, the latter prepares the individualised attribute data set, the individualisation taking into account: i) the area of present and future operations, ii) the specific characteristics of the bulldozer and iii) the tasks planned for the bulldozer in that area.

In the above example of the bulldozer, the site-working tool is more specifically a contour-modifying tool, inasmuch at it changes the height the surface. Some site-modifying tools useable with the present attribute data management method can operate on the site without changing the contour, the tool being e.g. a water sprinkler, a ground marking device, etc.

Figure 7 illustrates an example of the area of operation 68 for the bulldozer 36 for a given time window, calculated on

the basis of a current position of the bulldozer and its scheduled path, as determined by the mobile apparatus displacement manager 21. The area can be identified as a strip of determined width which covers the scheduled path. The width of that strip is determined on the basis of the characteristics of the bulldozer, of its contour-modifying tool 4, and the nature of the tasks to be performed along that path. Generally, the area is symmetrical about the line of path.

In order to economise on transmission bandwidth and on onboard memory space, only the cells C which cover the area of operation 68 are downloaded into the RAM 42 of the bulldozer 36.

For those cells, only the attribute data likely to be required by the bulldozer are incorporated in the individualised attribute data set, again to save on bandwidth and local memory space. Thus, the reduction of information in creating an individualised attribute data set operates on two levels: the topology of the cells (selection of only the pertinent cells) and the types of attribute data (selection of only the pertinent attribute data parameters), corresponding respectively to the x-y plane and the depth dimension of the attribute data space 6 (cf. figure 4). The aforementioned time window can be set as a function of one or several parameters among: the capacity of the RAM (a larger time window implies more data to cover more cells), the average speed of displacement, data traffic on the WLAN, etc.

Figure 8 shows the functional units involved in preparing an individualised attribute data set 70. The attribute data manager 18 is initially programmed with a table listing all the mobile apparatus of the worksite susceptible of exploiting attribute data. To each mobile apparatus are recorded the

selection attribute data parameters which it needs to carry on board. The mobile apparatus displacement manager 21 delivers to the attribute data manager 18 the path data MP covering a determined time window for a designated mobile apparatus. In response, the attribute data manager 18 determines the appropriate cells that adequately cover the corresponding area of operation 68 (cf. figure 7). By referring to the above table, it then accesses the attribute database 20 to extract, for each of those cells, the selected AD parameters that are relevant to the mobile apparatus concerned. These selected items of attribute data are arranged and formatted to be readable by the onboard CPU 40, and are mapped in accordance with the topology of the cells which constitute the area of operation 68. The individualised attribute data set 70 thereby comprises selected cells SC and values of selected AD parameters SP.

Note that as the pertinent AD parameters can be variable for a given mobile apparatus depending on the tasks to be conducted and the characteristics of the ground, the selected AD parameters used can be different for different cells.

The thus-compiled individualised attribute data set 70 is incorporated into the user data section of a message according to a predefined protocol and sent to the mobile apparatus by the wireless local area network. Upon receipt by the onboard communications interface 64, the individualised attribute data set 70 is extracted and stored in the onboard RAM 42. The storage is preferably managed according to a memory map following the topology of the area of operation 68. The AD parameter values can then be organised as a z dimension, according to a three-dimensional matrix that corresponds to a section of the attribute data space 6 (cf. figure 4), for the AD parameter values present in the individualised data set.

The cell locator unit 48 indicates to the other units the

cells at the location and in the immediate vicinity of the blade 4. The attribute data associated to those cells are loaded into the local attribute data manager 62, from which they can be accessed (instead of from the RAM 42) during the execution of the different tasks performed by the mobile apparatus.

In the above, the attribute data are downloaded from the on-site office to the mobile apparatus. It shall now be explained with reference to figure 9 how attribute data acquired at a local level by a mobile apparatus can be uploaded to the on-site office 14 for updating the attribute database 20. The figure shows the sensor management unit 52 controlling N different sensors numbered S1 to SN. Among these sensors are some whose acquired data correspond to AD parameters managed by the attribute data manager 18. If these sensors happen to be, say, sensors numbered 1, 3, 4, 8 and 11 and acquire AD parameter values SD1, SD3, SD4, SD8 and SD11 AD parameters, then the local attribute data manager 62 will periodically interrogate these sensors and order the uploading of both their data values, and the spatial coordinates at which they were acquired. This information is then uploaded to the on-site attribute data manager 18 through the wireless area network. The on-site attribute data manager identifies these AD parameter values and the AD parameters to which they apply, and enters those values in the corresponding field addresses of its attribute database 20. These addresses are defined in terms of the cells corresponding to the spatial coordinates and corresponding AD parameters. The interrogation can be conducted at the initiative of the local attribute data manager 62, or in response to a request from either the on-site attribute data manager 18 or another mobile or static unit on the worksite. In this manner, the attribute

database 20 is continuously updated for the fields whose attribute data are susceptible of evolving in the course of the tasks being conducted.

The attribute database 20 can also be managed to maintain a history of all attributes and their successive changes/updates as work progresses on the site. This history can serve e.g. to mitigate measurement errors and allow for plausibility checks. It can also provide a source for determining the rate of progress, work efficiency, future improvements in contour modifying procedures or tools, traceability, etc.

Figure 10 shows a variant of the above embodiment which differs by the fact that the entire data set forming the AD parameter values is contained in distributed databases 20a-20d, as opposed to a single storage entity. The overall operation remains the same, the attribute data manager 18 maintaining a table identifying, for each type of the AD parameters, the specific attribute database where that data is stored. In this manner, the attribute data manager 18 can operate seamlessly with the different databases for entering updated data, preparing individualised attribute data sets 70, etc.

In the illustrated example, the attribute data manager 18 operates with four separate AD parameter databases, identified by respective Roman numerals I-IV. Databases I and II are physically located off-site and are accessible by the attribute data manager 18 through an online server via the Internet 32. This could be the case, for example, if these databases respectively store the pre-surveyed attribute values and the administrative attribute values. Databases III and IV are both located on-site, but are physically separate units. Database III is connected to the attribute data manager 18 via a wire link 72 and is used, for example, to store the task

attribute values. Database IV is connected to the attribute data manager by a radio link over the wireless local area network and is used, for example, to store the real-time detected attribute values. With its wireless connection, this database can itself be managed as a mobile unit installed at variable locations on the worksite for optimum communication over the wireless local area network. In this manner, database IV can be conferred with the additional function of serving as a relay and/or communications hub in the local area network.

Figure 11 is a simplified diagram showing multiple items of mobile apparatus MA1-MA4 on the worksite communicating with the attribute data manager 18. The latter is informed in real-time by the mobile apparatus displacement manager 21 (cf. figure 6) of the current position (respectively P1-P4) of each mobile apparatus and, where applicable, the programmed path for the latter (respectively PA1-PA3). Note that a mobile apparatus need not necessarily have a programmed path. For instance, the item of mobile apparatus designated MA4 in the figure is a portable sensor unit carried by a human operator, who is given the initiative of his displacement over the worksite. This can be the case for example where the portable sensor unit is a gas detector which analyses chemical characteristics of outgassing emissions. The sensor unit can identify a gas composition, label it using a predetermined code and send at its initiative a message containing the gas composition code and the position coordinates of its point of detection. The latter are determined through a portable GPS unit carried by the operator, or by a total station used in the field of land surveying. The message is sent over the wireless local area network to the attribute data manager 18, where the code is read and entered as the attribute value in

the field corresponding to "gas type" (cf. figure 5a) for the cell corresponding to that position.

The attribute data manager 18 thereby receives and transmits multiple messages from and to the different mobile units, respectively for updating its complete set of attribute data and for downloading to those units the individualised attribute data they currently require, as explained above. In the example, the updated attribute values sent to the attribute data manager 18 are initially buffered, pre-processed and formatted into an update data message ADU sent to the attribute database 20 at short intervals.

It will be understood that the attribute data constitute information that is complementary to the data of the three-dimensional models of the initial and/or target contours. If these models use a grid system to define elementary unit areas with respect to a coordinate system, then it is advantageous to use the same grid system to define the cells C of the attribute data space (cf. figure 4). In other words, the elementary unit areas of the three-dimensional model and the cells C can be topologically positioned with a common mesh.

The acquisition of attribute can be effected using all types of devices and techniques, which can yield the corresponding data value either directly, or by inference. For instance, besides being acquired by the different sensors mentioned in the examples, the attribute can also be obtained by:

- total stations, i.e. surveying apparatus that determine range and elevation data,
- aerial sensors,
- aerial photography, where techniques such a photograph miscolour analysis, etc. can be used,
- local positioning systems (LPS),
- etc.

In some instances, some filtering of the information may be required to select from the complete set of different gathered data only those that are pertinent to a given recipient are transferred to the latter. The filtering criteria can take into account:

- the part of the site concerned, so that some types of data not necessary for a given portion (identified in terms of cells) can be filtered out, and/or
- the type of apparatus (site modifying tool, personnel, etc.) concerned.

The data filtering means can be positioned at the central office or delocalised to various levels of the work site, down to the mobile site-modifying apparatus itself.

The attribute data can, of course, differ in terms of type, category, number of items covered and formats attributed to its values, according to applications, the embodiment described simply being given as an example.

The management and storage of the attribute data can be implemented using a variety of hardware and software techniques. The presentation of the attribute data in accordance with the preferred embodiment, based on a three-dimensional attribute data space mapped against a topology of the worksite, is particularly well suited to some three-dimensional spreadsheet programs. Such spreadsheets are conceptually designed to present a depth dimension to a two-dimensional array of cells. In this case, the two-dimensional cell array can be made to correspond to the x-y coordinate plane on which the worksite is mapped, while the depth dimension is reserved for inserting corresponding attribute data parameter values. The depth of the spreadsheet, expressed in unit storage cells, can thereby be made to accommodate a corresponding depth of attribute data fields.

CLAIMS

1. Method of managing data relating to a work site area (12), comprising the steps of:

   - at an initial phase, establishing a set of at least one attribute parameter pertaining to an attribute of the work site, said attribute parameter having an attribute parameter value susceptible of varying as a function of position in said area (12),
   - subdividing said area into elementary cells (C) mapped in correspondence with the topology of said area,
   - for at least one said elementary cell, determining the attribute parameter value at that elementary cell of at least one attribute parameter,
   - storing attribute parameter values, each stored attribute parameter value being indexed to the elementary cell for which it was determined,
   - determining evolutions in attribute parameter values, and
   - dynamically updating said stored attribute parameter values on the basis of said determined evolutions.

2. Method according to claim 1, wherein each said attribute parameter expresses verified data or plausible data concerning an existing state of the work site.

3. Method according to claim 1 or 2, wherein said stored attribute parameter values are organised in a three-dimensional matrix of which the first and second dimensions map the topology of said work site area (12)

and define the locations of said elementary cells, and the third dimension corresponds to the set of attribute parameter(s).

4. Method according to any one of claims 1 to 3, wherein a said elementary cell is dimensioned as a function of at least one of:

- the variation in contour at said cell,
- the variation in contour at the immediate vicinity of said cell,
- the rate of variation with respect to position in the value of at least one data to be managed,
- the type of tool(s) scheduled to operate in the area occupied by said elementary cell.

5. Method according to any one of claims 1 to 4, wherein a said elementary cell is dimensioned to be smaller than the footprint of a tool scheduled to operate in the area occupied by said elementary cell, whereby an attribute parameter value relevant for the operation of said tool can be obtained with a determined degree of accuracy.

6. Method according to any one of claims 1 to 5, wherein dimensions of elementary cells are variable over said work site area (12).

7. Method according to any one of claims 1 to 6, wherein an attribute parameter relates to elementary cell dimensions, expressed by the attribute parameter value(s) of that attribute parameter.

8. Method according to any one of claims 1 to 7, wherein attribute parameter values are acquired and communicated and/or stored by mobile apparatus (36) as they are conducting site modifying tasks on the work site.

9. Method according to any one of claims 1 to 8, wherein said data to be managed are acquired and communicated and/or stored by mobile apparatus (RA4) moving on the work site (12) specifically for acquiring and communicating and/or storing said attribute parameter value(s).

10. Method according to any one of claims 8 or 9, comprising the steps of:

- interrogating at least one source (54-60) of dynamically updatable data on board said mobile apparatus (36), capable of delivering at least one current attribute parameter value,
- determining the geographical location at which said current value(s) is/are acquired, and
- storing said attribute parameter value(s) acquired at said interrogating step, in association with the cell corresponding to the said determined geographical location, as an updated attribute parameter value.

11. Method according to claim 10, wherein said updated parameter value is sent to a remote data management resource (18) for dynamically updating said stored data values by the steps of:

- forming a message containing said attribute parameter

value(s) and said geographical location data, and

- sending said message to said remote data management resource.

12. Method according to claim 11, wherein said message forming and sending steps are performed on board said mobile apparatus (36).

13. Method according to any one of claims 1 to 9, comprising the steps of:

- interrogating at least one source (54-60) of dynamically updatable data on board said mobile apparatus (36), capable of delivering at least one current attribute parameter value,
- determining the geographical location at which said current value(s) is/are acquired,
- associating and locally storing said current attribute parameter value(s) and said geographical location data on board said mobile apparatus.

14. Method according to claim 13, further comprising the step of uploading said attribute parameter value(s) and said geographical location data from said mobile apparatus to a remote data management resource at a determined updating moment.

15. Method according to any one of claims 8 to 14, wherein said dynamically updatable attribute parameter value(s) are acquired and communicated on-the-fly as said mobile apparatus (34, RA1-RA4) evolves over said area.

16. Method according to any one of claims 1 to 15, wherein said data to be managed relate to physical or chemical characteristics of said work site and/or physical or chemical atmospheric characteristics of said work site.

17. Method according to any one of claims 1 to 16, wherein said data to be managed comprises at least one of the following types of data for the region occupied by a said cell:

- ground humidity,
- ambient air humidity,
- ground temperature,
- ambient air temperature,
- ground density,
- outgassing characteristics,
- chemical or physical composition data of material,
- mechanical characteristic data of material,
- optical characteristics of material, e.g. colour, reflectivity,
- qualitative information on at least one operation to be carried out, e.g. a cut or fill indication.

18. Method according to any one of claims 1 to 17, wherein at least one dynamically updated attribute parameter value is acquired by a sensor (54-60) specifically provided for sensing that attribute parameter.

19. Method according to any one of claims 1 to 18, wherein at least one dynamically updated attribute parameter value is inferred from operating parameters of a site-modifying apparatus (36) operative in said work site area.

20. Method according to any one of claims 1 to 19, wherein said attribute parameter value(s) further comprises at least one attribute parameter value established prior to site modifying operations on said work site.

21. Method according to claim 20, wherein at least one attribute parameter value established prior to site modifying operations on said work site relates to a non-dynamic land characteristic of said work site (12).

22. Method according to claim 20 or 21, wherein said at least one at least one attribute parameter value established prior to site modifying operations on said work site comprises at least one of:

- soil type,
- land composition at a specified depth or depth range,
- possible existence of a buried conduit,
- indication of the type of buried conduit,
- possible existence of an underground cavity,
- indication of the type of underground cavity,
- recorded or supposed position of a buried conduit or underground cavity.

23. Method according to any one of claims 20 to 22, wherein

said at least one at least one attribute parameter value established prior to site modifying operations on said work site relates to operating characteristics of said mobile apparatus (36).

24. Method according to any one of claims 19 to 23, wherein said at least one data value established prior to site modifying operations on said work site relates to legal, administrative, or contractual data associated to said work site.

25. Method according to claim 24, wherein said legal, administrative, or contractual data relates to at least one of:

- land ownership,
- insurance coverage,
- assigned contractor,
- task cost,
- task priority,
- legal status,
- possible existence of a toxic hazard,
- indication of archaeological interest.

26. Method according to any of claims 1 to 25, wherein a said attribute parameter is a communications parameter, e.g. radio frequency, for exchanging data with a remote resource (24).

27. Method according to any one of claims 1 to 26, wherein at least one attribute parameter relates to a reference level, its attribute parameter value for a cell expressing reference level value with respect to which elevation/depth values are established for that cell.

28. Method according to any one of claims 1 to 27, further comprising the step of preparing an individualised dataset (70) specific to an identified site-modifying mobile apparatus (36), said individualised dataset comprising selected attribute parameter values for the requirements of that site-modifying mobile apparatus.

29. Method according to claim 28, wherein said individualised dataset relates only to cells at, and in the immediate vicinity of, said site-modifying apparatus (36) at a current geographical location of the latter.

30. Method according to claim 29, wherein said individualised dataset relates only to cells of a region (68) of said work site where said site-modifying apparatus (36) is programmed to be present over a determined time window.

31. Method according to any one of claims 28 to 30, wherein said individualised dataset relates only to attribute parameter data, among the stored attribute parameter values, which are relevant to said site-modifying apparatus (36).

32. Method according to any one of claims 1 to 31, wherein said attribute parameter values are centralised at a main

database (20).

33. Method according to any one of claims 1 to 31, wherein said attribute parameter values are distributed over plural distributed databases (20a-20d).

34. Apparatus for managing data relating to a work site area (12) comprising:

- means, operative at an initial phase, for establishing a set of at least one attribute parameter pertaining to an attribute of the work site, said attribute parameter having an attribute parameter value susceptible of varying as a function of position in said area (12),
- mapping means storing a set of elementary cells (C) which subdivide said area in correspondence with the topology of said area,
- means for determining the attribute parameter value at that elementary cell, for at least one attribute parameter,
- storage means (20) for storing attribute parameter values, each stored attribute parameter value being indexed to the elementary cell for which it is determined,
- means for determining evolutions in attribute parameter values, and
- means for dynamically updating said stored attribute parameter values on the basis of said determined evolutions.

35. Apparatus according to claim 34, wherein each said attribute parameter value expresses verified data or plausible data concerning an existing condition of the work site.

36. Apparatus according to claim 34 or 35, wherein said stored attribute parameter values are organised in a three-dimensional matrix of which the first and second dimensions map the topology of said work site area (12) and define the locations of said elementary cells, and the third dimension corresponds to the attribute parameter(s).

37. Apparatus according to any one of claims 34 to 36, comprising means on board mobile apparatus (36) for acquiring and communicating and/or storing said attribute parameter value(s).

38. Apparatus according to any one of claims 34 to 37, comprising:

- means for interrogating at least one source (54-60) of dynamically updatable data on board said mobile apparatus (36), capable of delivering at least one current attribute parameter value,
- means for determining the geographical location at which said current value(s) is/are acquired, and
- means for storing said attribute parameter value(s) acquired at said by said interrogating means, in association with the cell corresponding to the said determined geographical location, as an updated attribute parameter value.

39. Apparatus according to claim 38, further operative for sending said updated parameter value to a remote data management resource (18) for dynamically updating said stored data values, said apparatus further comprising:

- means for forming a message containing said attribute parameter value(s) and said geographical location data, and

- means for sending said message to said remote data management resource (18).

40. Apparatus according to claim 39, wherein said message forming means and message sending means are located on board said mobile apparatus (36).

41. Apparatus according to any one of claims 34 to 40, comprising:

- means for interrogating at least one source (54-60) of dynamically updatable data on board said mobile apparatus (36), capable of delivering at least one current attribute parameter value,

- means for determining the geographical location at which said current attribute parameter value(s) is/are acquired,

- means for associating and locally storing said current attribute parameter value(s) and said geographical location data on board said mobile apparatus, and

- means for downloading said associated data for dynamically updating said stored attribute parameter values at a determined updating time.

42. Apparatus according to any one of claims 34 to 41, further comprising means for acquiring said attribute parameter value(s), said means being at least one of:

- a total station type of surveying device,
- an aerial view sensor,
- a GPS (global positioning by satellite) device,
- An LPS (local positioning system).

43. Apparatus according to any one of claims 34 to 42, comprising means for inferring at least one attribute parameter value from operating parameters of a site-modifying apparatus (36) active in said work site area.

44. Apparatus according to any one of claims 34 to 43, further comprising data filtering means for selecting, from the stored attribute parameter values, those items of information relevant to at least one of:

- selected cells,
- selected site-modifying apparatus,
- selected tasks on said work site,

and means for sending said filtered information to targeted recipients.

45. A data base (20) comprising a single storage unit or distributed storage units, containing attribute parameter values, said attribute parameter values being prepared specifically for the execution of the method according to any one of claims 1 to 33.

46. A storage medium containing an individualised dataset (70) specific to an identified site-modifying mobile apparatus (36), said individualised dataset being prepared specifically for the execution of the method according to any one claims 1 to 33, and comprising selected data elements of said attribute parameters for the specific requirements of that site-modifying mobile apparatus.

47. Storage medium according to claim 46, wherein said individualised dataset relates only to cells at, and in the immediate vicinity of, said site-modifying apparatus (36) at a current geographical location of the latter.

48. Storage medium according to claim 47, wherein said individualised dataset relates only to cells of a region (68) of said work site where said contour-modifying apparatus (36) is programmed to be present over a determined time window.

49. Storage medium according to any one of claims 46 to 48, wherein said individualised dataset relates only to a/those attribute parameter value(s) among the set managed data, which is/are relevant to said site-modifying apparatus (36).

50. A data carrier containing code executable by processor means, to cause said processor means to carry out the method according to any of claims 1 to 33.

51. Code executable by processor means, said code causing said

processor means to carry out the method according to any of claims 1 to 33.

ABSTRACT

Data relating to a work site area (12) are managed by:

- at an initial phase, establishing a set of at least one attribute parameter pertaining to an attribute of the work site, said attribute parameter having an attribute parameter value susceptible of varying as a function of position in said area (12),
- subdividing said area into elementary cells (C) mapped in correspondence with the topology of said area,
- for at least one said elementary cell, determining the attribute parameter value at that elementary cell of at least one attribute parameter,
- storing attribute parameter values, each stored attribute parameter value being indexed to the elementary cell for which it was determined,
- determining evolutions in attribute parameter values, and
- dynamically updating said stored attribute parameter values on the basis of said determined evolutions.

Each attribute parameter can expresses verified data or plausible data concerning an existing state of the work site.

The stored attribute parameter values are preferably organised in a three-dimensional matrix of which the first and second dimensions map the topology of said work site area (12) and define the locations of said elementary cells, and the third dimension corresponds to the set of attribute parameter(s).

Figure 6

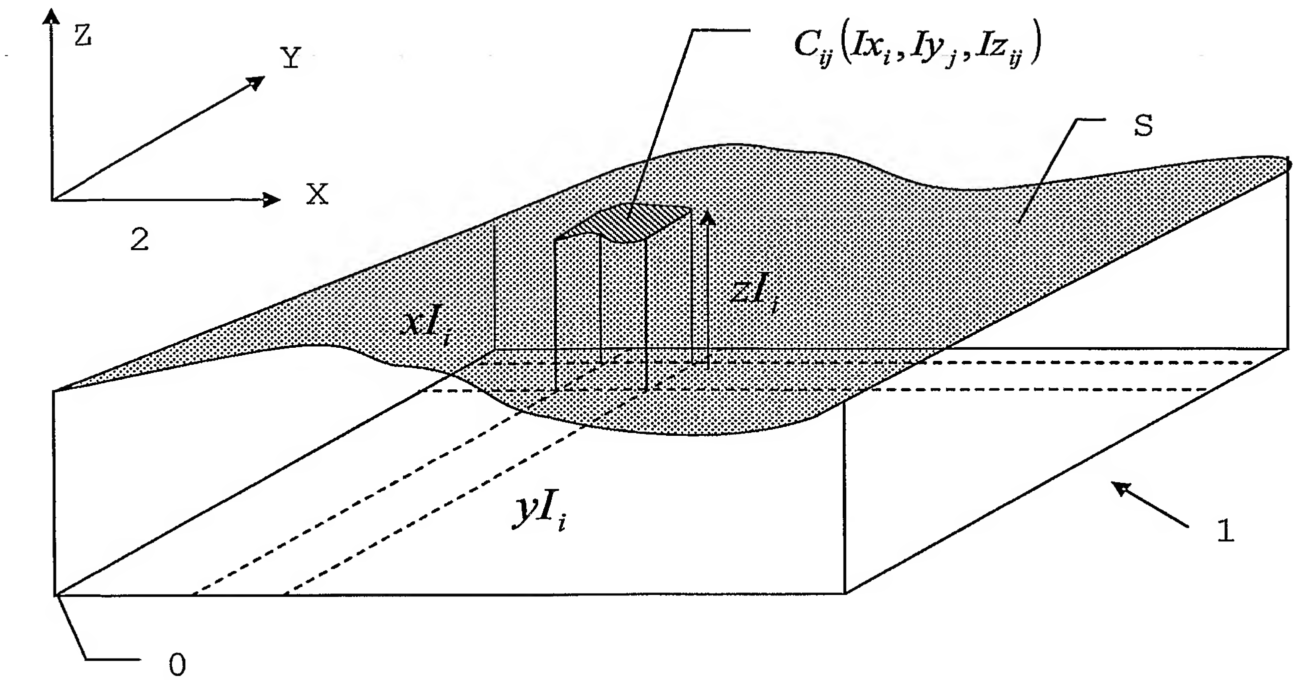


Fig.1

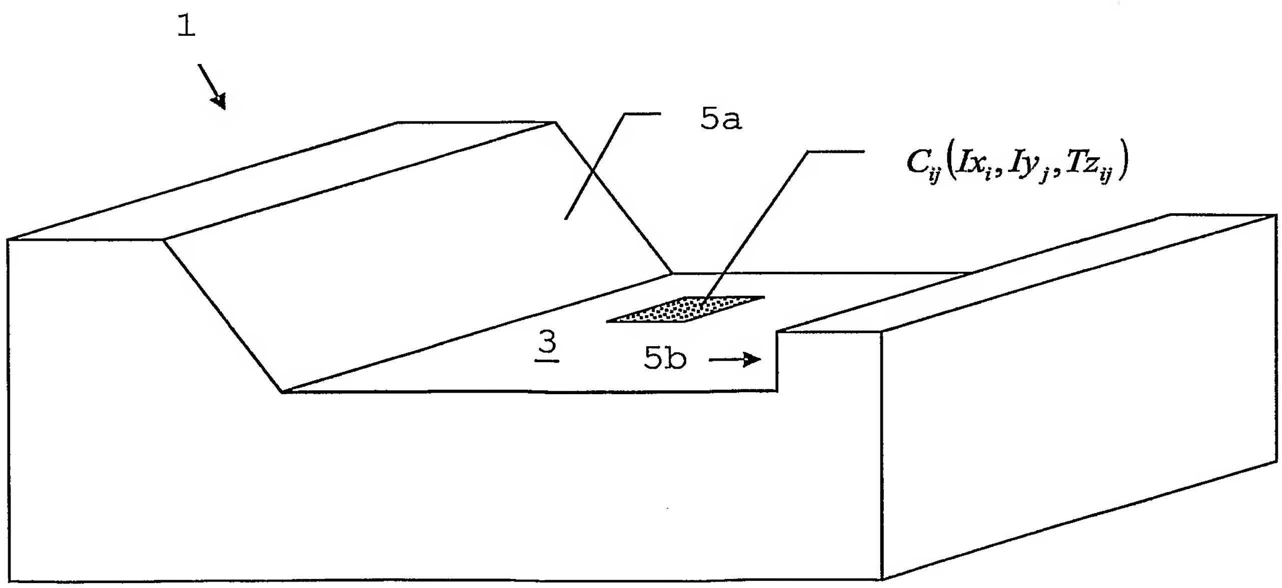
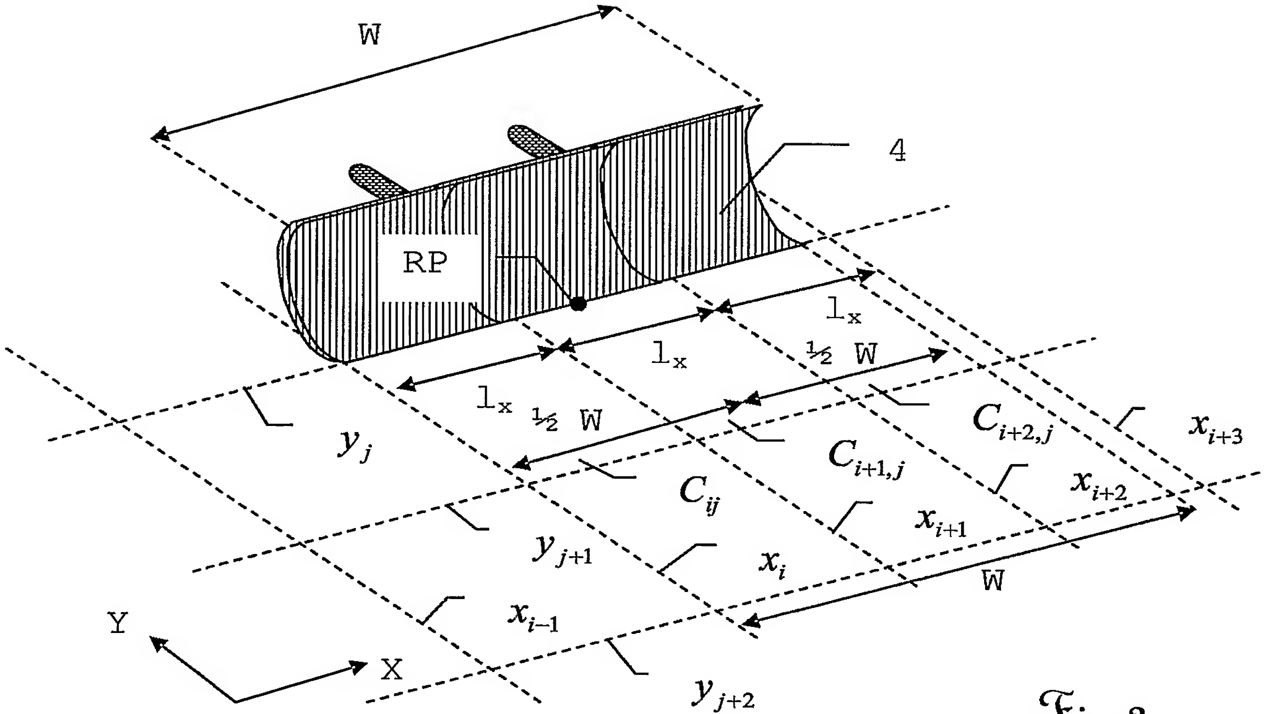


Fig.2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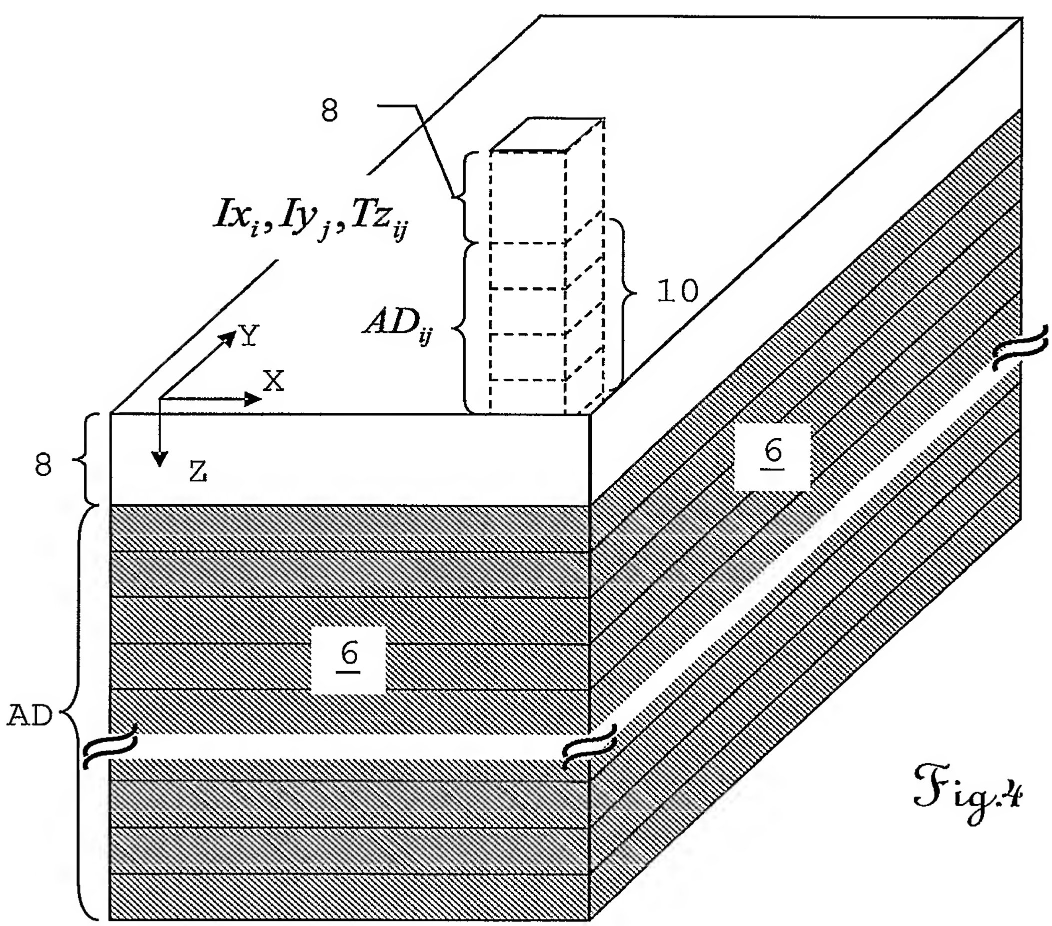
4
RP
l_x
l_x
l_x
½ W
½ W
y_j
$C_{i+2,j}$
x_{i+3}
$C_{i+1,j}$
C_{ij}
x_{i+2}
x_{i+1}
y_{j+1}
x_i
W
Y
x_{i-1}
X
y_{j+2}

Fig.3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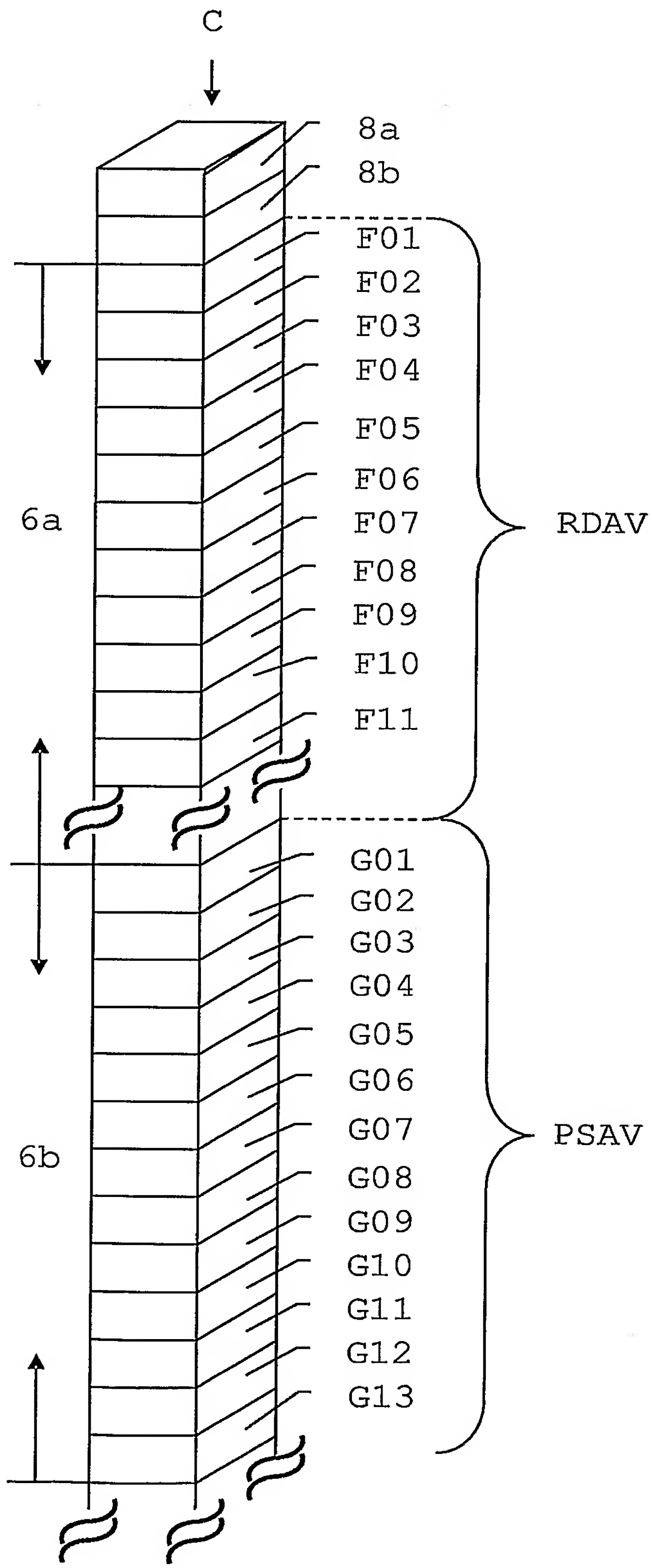
Ix_i, Iy_j, Tz_{ij}
10
AD_{ij}
Y
X
8
Z
6
6
AD

Fig.4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8a
8b
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F02
F03
F04
F05
F06
F07
F08
F09
F10
F11
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G01
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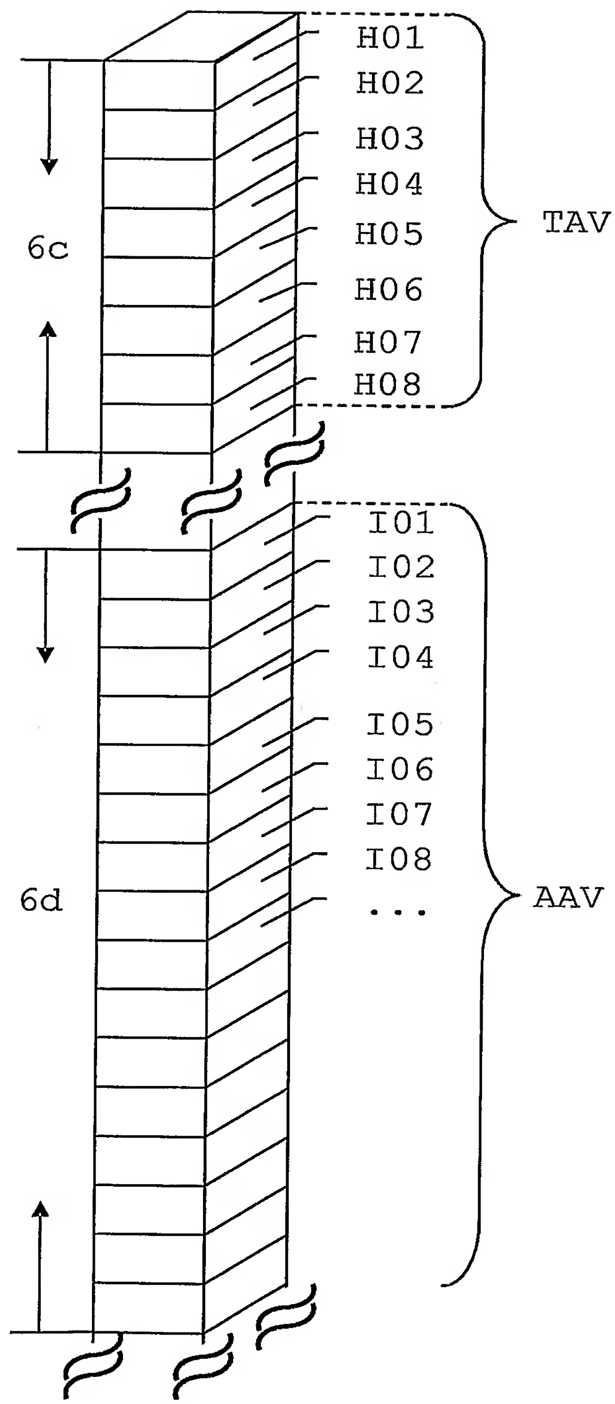
G12
G13
PSAV
6b

Fig.5a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H02
H03
H04
H05
H06
H07
H08
TAV
6c
I01
I02
I03
I04
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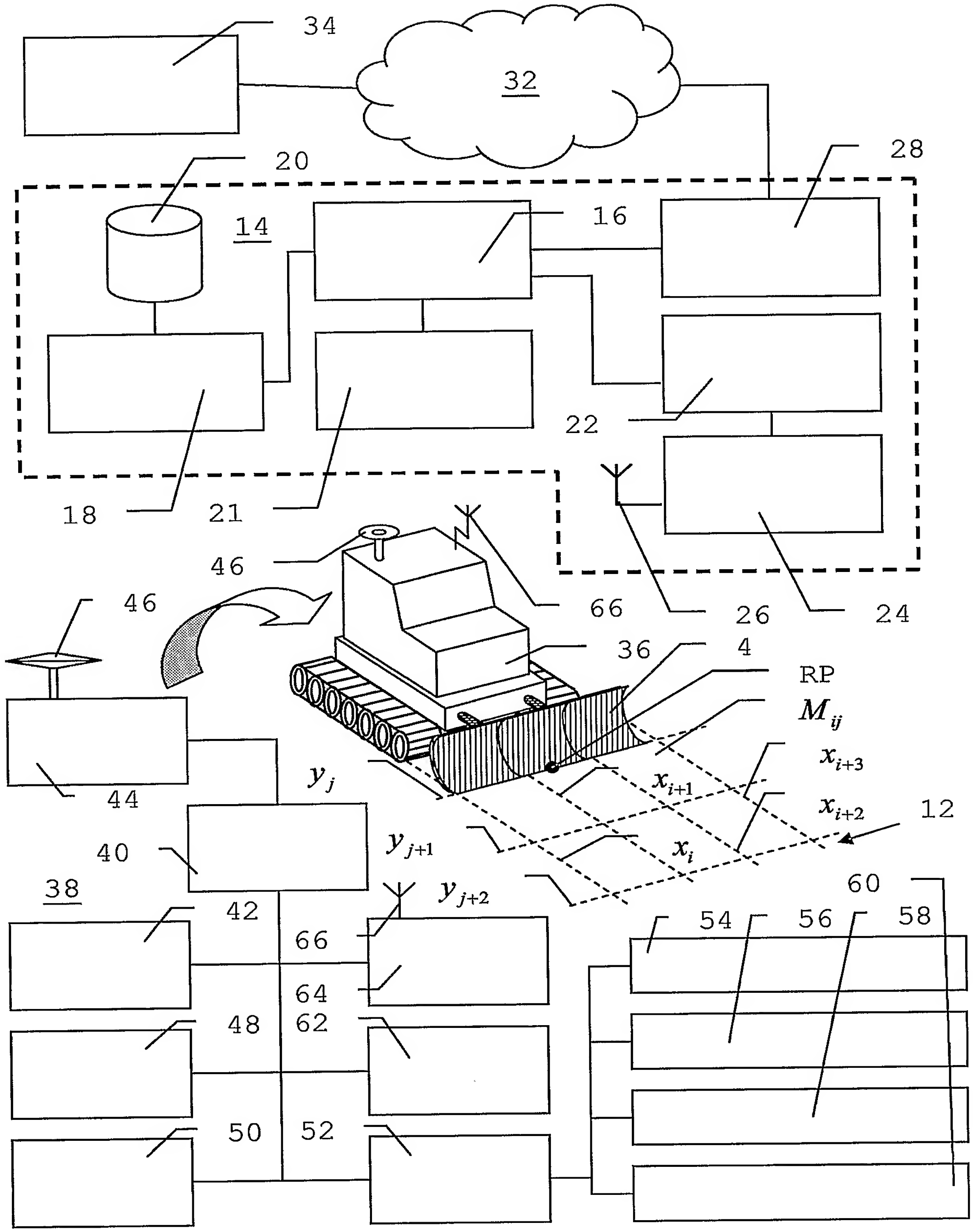
I06
I07
I08
...
AAV
6d

Fig.5b


34
32
20
28
14
16
22
18
21
46
46
66
26
24
36
4
RP
M_{ij}
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x_{i+3}
44
x_{i+1}
x_{i+2}
12
40
y_{j+1}
x_i
38
y_{j+2}
60
42
54
56
58
66
64
48
62
50
52

Fig.6

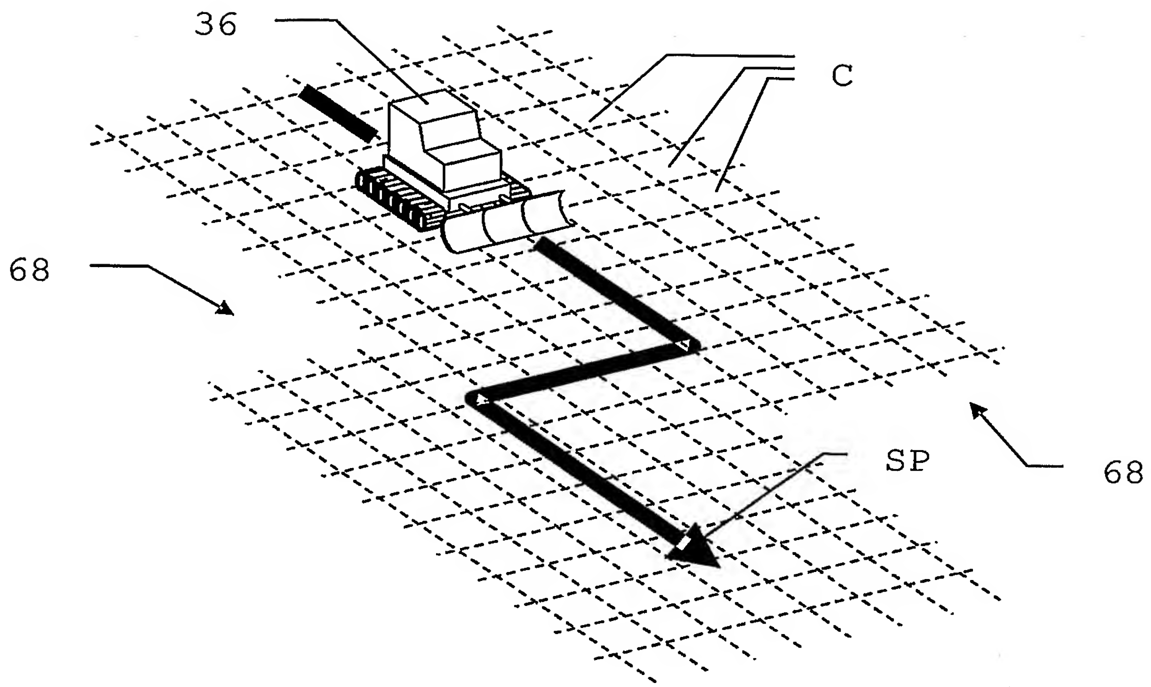

Fig.7

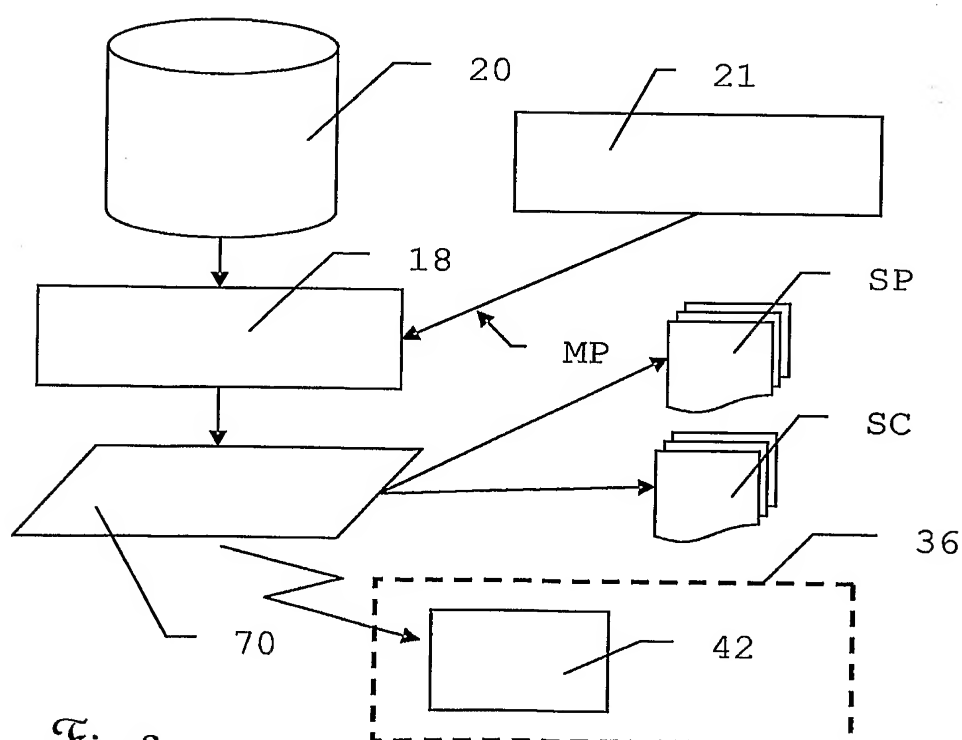

Fig.8

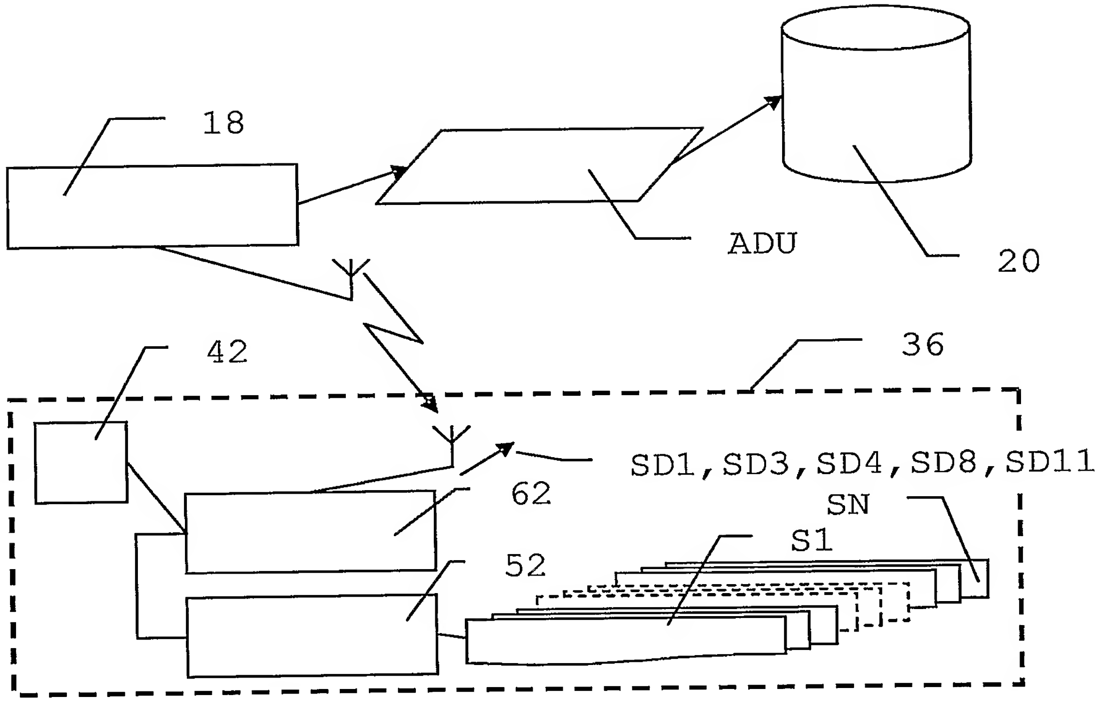
18
ADU
20
42
36
SD1,SD3,SD4,SD8,SD11
62
SN
S1
52

Fig.9

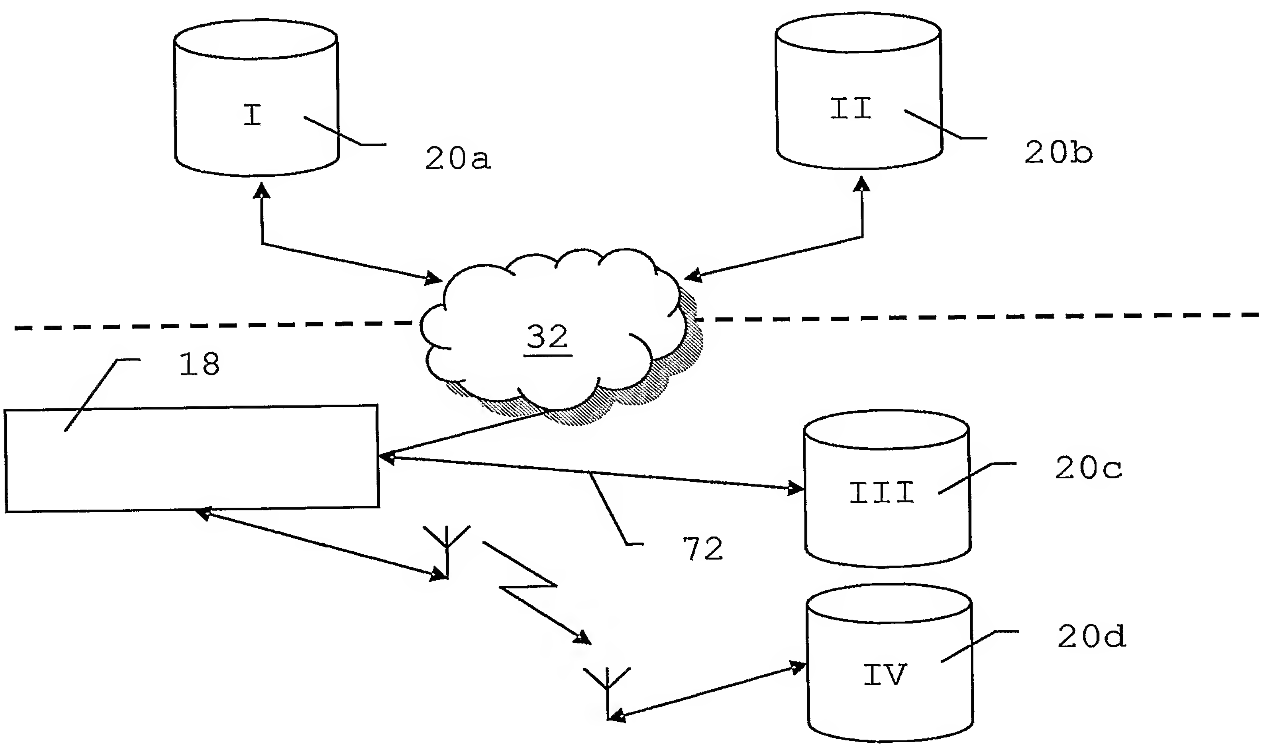
I
20a
II
20b
32
18
III
20c
72
IV
20d

Fig.10

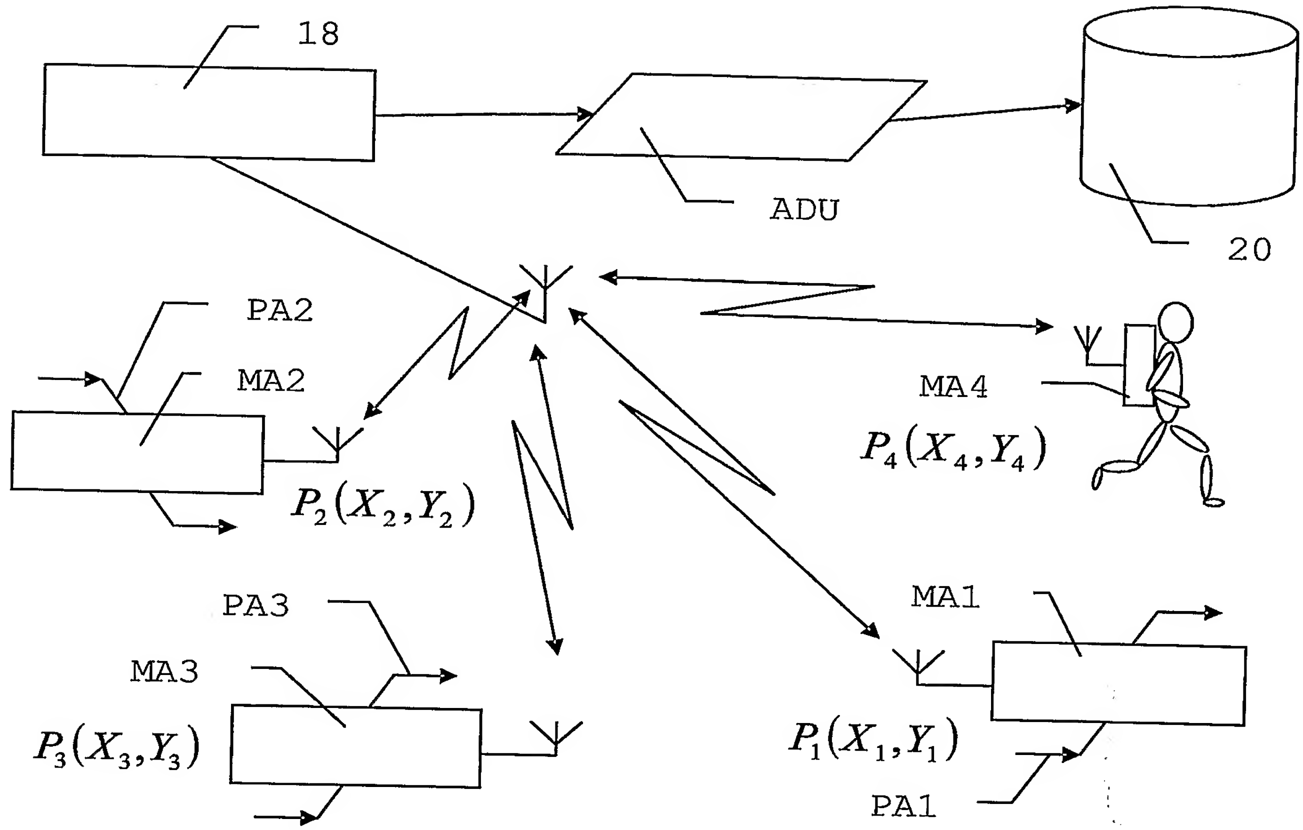
18
ADU
20
PA2
MA2
$P_2(X_2,Y_2)$
MA4
$P_4(X_4,Y_4)$
PA3
MA3
$P_3(X_3,Y_3)$
MA1
$P_1(X_1,Y_1)$
PA1

Fig.11